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"Hydrocarbons" are generally defined as molecules formed primarily by carbon and hydrogen atoms. Hydrocarbons may also include other elements, such as, but not limited to, halogens, metallic elements, nitrogen, oxygen, and/or sulfur.

On page 53, please delete the paragraph beginning on line 20, and substitute therefor:

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As shown in FIG. 3, in addition to heat sources 100, one or more production wells 104 will typically be disposed within the portion of the coal formation. Formation fluids may be produced through production well 104. Production well 104 may also include a heat source. In this manner, the formation fluids may be maintained at a selected temperature throughout production, thereby allowing more or all of the formation fluids to be produced as vapors. Therefore high temperature pumping of liquids from the production well may be reduced or substantially eliminated, which in turn decreases production costs. Providing heating at or through the production well tends to: (1) inhibit condensation and/or refluxing of production fluid when such production fluid is moving in the production well proximate to the overburden, (2) increase heat input into the formation, and/or (3) increase formation permeability at or proximate the production well.

In The Claims:

Listed below is a clean copy of amended claims. A marked-up copy indicating the amended sections of the claims is provided in an accompanying document.

Please amend the claims as follows:

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2424. (amended) A method of treating a coal formation in situ, comprising:
providing heat from one or more heaters to at least a portion of the formation;
allowing the heat to transfer from the one or more heaters to a part of the formation; and
producing a mixture from the formation through one or more production wells, wherein
the heating is controlled such that the mixture is produced from the formation as a vapor, and

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wherein at least about 7 heaters are disposed in the formation for each production well.

2425. (amended) The method of claim 2424, wherein the one or more heaters comprise at least two heaters, and wherein superposition of heat from at least the two heaters pyrolyzes at least some hydrocarbons within the part of the formation.

2426. (amended) The method of claim 2424, further comprising maintaining a temperature within the part of the formation within a pyrolysis temperature range of about 270 °C to about 400 °C.

2427. (amended) The method of claim 2424, wherein the one or more heaters comprise electrical heaters.

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2428. (amended) The method of claim 2424, wherein the one or more heaters comprise surface burners.

2429. (amended) The method of claim 2424, wherein the one or more heaters comprise flameless distributed combustors.

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2430. (amended) The method of claim 2424, wherein the one or more heaters comprise natural distributed combustors.

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2431. (amended) The method of claim 2424, further comprising controlling a pressure and a temperature within at least a majority of the part of the formation, wherein the pressure is controlled as a function of temperature, or the temperature is controlled as a function of pressure.

2432. (amended) The method of claim 2424, further comprising controlling the heat such that an average heating rate of the part of the formation is less than about 1 °C per day within a pyrolysis temperature range of about 270 °C to about 400 °C.

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2433. (amended) The method of claim 2424, wherein providing heat from the one or more heaters to at least the portion of formation comprises:

heating a selected volume (V) of the coal formation from the one or more heaters, wherein the formation has an average heat capacity (C_v), and wherein the heating pyrolyzes at least some hydrocarbons within the selected volume of the formation; and

wherein heating energy/day (P_{hr}) provided to the selected volume is equal to or less than $h * V * C_v * \rho_B$, wherein ρ_B is formation bulk density, and wherein an average heating rate of the formation (h) is about 10 °C/day.

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2435. (amended) The method of claim 2424, wherein providing heat from the one or more heaters comprises heating the part of the formation such that a thermal conductivity of at least a portion of the part of the formation is greater than about 0.5 W/(m °C).

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2447. (amended) The method of claim 2424, wherein the produced mixture comprises a non-condensable component, wherein the non-condensable component comprises molecular hydrogen, wherein the molecular hydrogen is greater than about 10 % by volume of the non-condensable component, and wherein the molecular hydrogen is less than about 80 % by volume of the non-condensable component.

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2457. (amended) The method of claim 2424, wherein allowing the heat to transfer comprises increasing a permeability of a majority of the part of the formation to greater than about 100 millidarcy.

2458. (amended) The method of claim 2424, wherein allowing the heat to transfer comprises substantially uniformly increasing a permeability of a majority of the part of the formation.

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2460. (amended) The method of claim 2424, further comprising providing heat from three or more heaters to at least a portion of the formation, wherein three or more of the heaters are located in the formation in a unit of heaters, and wherein the unit of heaters comprises a triangular pattern.

2461. (amended) The method of claim 2424, further comprising providing heat from three or more heaters to at least a portion of the formation, wherein three or more of the heaters are located in the formation in a unit of heaters, wherein the unit of heaters comprises a triangular pattern, and wherein a plurality of the units are repeated over an area of the formation to form a repetitive pattern of units.

Please add the following new claims:

5150. (new) The method of claim 2424, wherein the part of the formation comprises a selected section.

5151. (new) The method of claim 2424, wherein the part of the formation comprises a pyrolysis zone.

5152. (new) The method of claim 2424, wherein the part of the formation comprises a pyrolysis zone proximate to and/or surrounding at least one of the one or more heaters.

5153. (new) The method of claim 2424, wherein at least one of the one or more heaters is disposed in an open wellbore.

5154. (new) A method of treating a coal formation in situ, comprising:
providing heat from one or more heaters to at least a portion of the formation;
allowing the heat to transfer from the one or more heaters to a part of the formation; and
producing a mixture from the formation through one or more production wells, wherein at least about 7 heaters are disposed in the formation for each production well.

5155. (new) The method of claim 5154, wherein the part of the formation comprises a selected section.

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5156. (new) The method of claim 5154, wherein the part of the formation comprises a pyrolysis zone.

5157. (new) The method of claim 5154, wherein the part of the formation comprises a pyrolysis zone proximate to and/or surrounding at least one of the one or more heaters.

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5158. (new) The method of claim 5154, wherein at least one of the one or more heaters is disposed in an open wellbore.

5159. (new) The method of claim 5154, wherein the one or more heaters comprise at least two heaters, and wherein superposition of heat from at least the two heaters pyrolyzes at least some hydrocarbons within the part of the formation.

5160. (new) The method of claim 5154, further comprising maintaining a temperature within the part of the formation within a pyrolysis temperature range of about 270 °C to about 400 °C.

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5161. (new) The method of claim 5154, wherein the one or more heaters comprise electrical heaters.

5162. (new) The method of claim 5154, wherein the one or more heaters comprise surface burners.

5163. (new) The method of claim 5154, wherein the one or more heaters comprise flameless distributed combustors.

5164. (new) The method of claim 5154, wherein the one or more heaters comprise natural distributed combustors.

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5165. (new) The method of claim 5154, further comprising controlling a pressure and a temperature within at least a majority of the part of the formation, wherein the pressure is controlled as a function of temperature, or the temperature is controlled as a function of pressure.

5166. (new) The method of claim 5154, further comprising controlling the heat such that an average heating rate of the part of the formation is less than about 1 °C per day within a pyrolysis temperature range of about 270 °C to about 400 °C.

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5167. (new) The method of claim 5154, wherein providing heat from the one or more heaters to at least the portion of formation comprises:

heating a selected volume (V) of the coal formation from the one or more heaters, wherein the formation has an average heat capacity (C_v), and wherein the heating pyrolyzes at least some hydrocarbons within the selected volume of the formation; and

wherein heating energy/day (P_{wr}) provided to the selected volume is equal to or less than $h \cdot V \cdot C_v \cdot \rho_B$, wherein ρ_B is formation bulk density, and wherein an average heating rate of the formation (h) is about 10 °C/day.

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5168. (new) The method of claim 5154, wherein allowing the heat to transfer comprises transferring heat substantially by conduction.

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5169. (new) The method of claim 5154, wherein providing heat from the one or more heaters comprises heating the part of the formation such that a thermal conductivity of at least a portion of the part of the formation is greater than about 0.5 W/(m °C).

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5170. (new) The method of claim 5154, wherein the produced mixture comprises condensable hydrocarbons having an API gravity of at least about 25°.

5171. (new) The method of claim 5154, wherein the produced mixture comprises condensable hydrocarbons, and wherein about 0.1 % by weight to about 15 % by weight of the condensable hydrocarbons are olefins.

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5172. (new) The method of claim 5154, wherein the produced mixture comprises non-condensable hydrocarbons, and wherein a molar ratio of ethene to ethane in the non-condensable hydrocarbons ranges from about 0.001 to about 0.15.

5173. (new) The method of claim 5154, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is nitrogen.

5174. (new) The method of claim 5154, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is oxygen.

5175. (new) The method of claim 5154, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is sulfur.

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5176. (new) The method of claim 5154, wherein the produced mixture comprises condensable hydrocarbons, wherein about 5 % by weight to about 30 % by weight of the condensable hydrocarbons comprise oxygen containing compounds, and wherein the oxygen containing compounds comprise phenols.

5177. (new) The method of claim 5154, wherein the produced mixture comprises condensable hydrocarbons, and wherein greater than about 20 % by weight of the condensable hydrocarbons are aromatic compounds.

5178. (new) The method of claim 5154, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 5 % by weight of the condensable hydrocarbons comprises multi-ring aromatics with more than two rings.

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5179. (new) The method of claim 5154, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 0.3 % by weight of the condensable hydrocarbons are asphaltenes.

5180. (new) The method of claim 5154, wherein the produced mixture comprises condensable hydrocarbons, and wherein about 5 % by weight to about 30 % by weight of the condensable hydrocarbons are cycloalkanes.

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5181. (new) The method of claim 5154, wherein the produced mixture comprises a non-condensable component, wherein the non-condensable component comprises molecular hydrogen, wherein the molecular hydrogen is greater than about 10 % by volume of the non-condensable component, and wherein the molecular hydrogen is less than about 80 % by volume of the non-condensable component.

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5182. (new) The method of claim 5154, wherein the produced mixture comprises ammonia, and wherein greater than about 0.05 % by weight of the produced mixture is ammonia.

5183. (new) The method of claim 5154, wherein the produced mixture comprises ammonia, and wherein the ammonia is used to produce fertilizer.

5184. (new) The method of claim 5154, further comprising controlling a pressure within at least a majority of the part of the formation, wherein the controlled pressure is at least about 2.0 bar absolute.

5185. (new) The method of claim 5154, further comprising controlling formation conditions to produce the mixture, wherein a partial pressure of H₂ within the mixture is greater than about 0.5 bar.

5186. (new) The method of claim 5185, wherein the partial pressure of H₂ within the mixture is measured when the mixture is at a production well.

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5187. (new) The method of claim 5154, further comprising altering a pressure within the formation to inhibit production of hydrocarbons from the formation having carbon numbers greater than about 25.

5188. (new) The method of claim 5154, further comprising controlling formation conditions by recirculating a portion of hydrogen from the mixture into the formation.

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5189. (new) The method of claim 5154, further comprising:
providing hydrogen (H₂) to the heated section to hydrogenate hydrocarbons within the section; and
heating a portion of the section with heat from hydrogenation.

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5190. (new) The method of claim 5154, further comprising:
producing hydrogen and condensable hydrocarbons from the formation; and
hydrogenating a portion of the produced condensable hydrocarbons with at least a portion of the produced hydrogen.

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5191. (new) The method of claim 5154, wherein allowing the heat to transfer comprises increasing a permeability of a majority of the part of the formation to greater than about 100 millidarcy.

5192. (new) The method of claim 5154, wherein allowing the heat to transfer comprises substantially uniformly increasing a permeability of a majority of the part of the formation.

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5193. (new) The method of claim 5154, wherein the heating is controlled to yield greater than about 60% by weight of condensable hydrocarbons, as measured by Fischer Assay.

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5194. (new) The method of claim 5154, further comprising providing heat from three or more heaters to at least a portion of the formation, wherein three or more of the heaters are located in the formation in a unit of heaters, and wherein the unit of heaters comprises a triangular pattern.

5195. (new) The method of claim 5154, further comprising providing heat from three or more heaters to at least a portion of the formation, wherein three or more of the heaters are located in the formation in a unit of heaters, wherein the unit of heaters comprises a triangular pattern, and wherein a plurality of the units are repeated over an area of the formation to form a repetitive pattern of units.

5196. (new) A method of treating a coal formation in situ, comprising:
providing heat from one or more heaters to at least a portion of the formation;
allowing the heat to transfer from the one or more heaters to a part of the formation; and
producing a mixture from the formation through one or more production wells, wherein the heating is controlled such that substantially all of the mixture is produced from the formation as a vapor, and wherein at least about 7 heaters are disposed in the formation for each production well.

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5197. (new) The method of claim 5196, wherein the part of the formation comprises a selected section.

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5198. (new) The method of claim 5196, wherein the part of the formation comprises a pyrolysis zone.

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5199. (new) The method of claim 5196, wherein the part of the formation comprises a pyrolysis zone proximate to and/or surrounding at least one of the one or more heaters.

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5200. (new) The method of claim 5196, wherein at least one of the one or more heaters is disposed in an open wellbore.

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5201. (new) The method of claim 5196, wherein at least one of the one or more heat sources comprise natural distributed combustors.

5202. (new) The method of claim 5196, wherein the produced mixture comprises condensable hydrocarbons having an API gravity of at least about 25°.

5203. (new) The method of claim 5196, further comprising controlling a pressure and a temperature within at least a majority of the part of the formation, wherein the pressure is controlled as a function of temperature, or the temperature is controlled as a function of pressure.

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5204. (new) The method of claim 5196, wherein allowing the heat to transfer comprises substantially uniformly increasing a permeability of a majority of the part of the formation.

5205. (new) The method of claim 5196, wherein providing heat from the one or more heaters to at least the portion of formation comprises:

heating a selected volume (V) of the coal formation from the one or more heaters, wherein the formation has an average heat capacity (C_v), and wherein the heating pyrolyzes at least some hydrocarbons within the selected volume of the formation; and

wherein heating energy/day (Pwr) provided to the selected volume is equal to or less than $h * V * C_v * \rho_B$, wherein ρ_B is formation bulk density, and wherein heating rate (h) is about 10 °C/day. (new)

Response To Office Action Mailed May 20, 2002

A. Pending Claims

Claims 2424-2426, 2430-2449, 2457, 2458, 2460, 2461, and 5150-5205 are pending in the case. Claims 2424-2433, 2435, 2447, 2457, 2458, 2460, and 2461 have been amended. Claims 5150-5205 are new.

B. Submission of Corrected Formal Drawings

In the Office Action mailed May 20, 2002, the Examiner indicated approval of the proposed drawing corrections filed on March 11, 2002 [mailed on February 25, 2002]. Applicant herewith submits the corrected formal drawings approved by the Examiner (seven sheets, including FIGS. 23a, 23b, 32, 44, 54, 55, 59, 60, and 63).

C. Examiner Interview

Applicant's undersigned attorney attended an interview with the Examiner and other personnel on August 19, 2002. In the interview all of the cited art, and certain other prior art (e.g., Ljungstrom) was discussed. In addition, the rejections set forth in the office action, and the claims were discussed. Claim amendments were also discussed. Applicant sincerely appreciates the Examiner taking the time to discuss the case.

D. Provisional Double Patenting Rejection

The Examiner provisionally rejected claims 2424-2449, 2457-2458, and 2460-2461 under the judicially created doctrine of obviousness-type double patenting as being unpatentable over claims of copending U.S. Patent Application Nos.:

09/840,936; 09/840,937; 09/841,000; 09/841,060, 09/841,127; 09/841,128;
09/841,129; 09/841,130; 09/841,131; 09/841,170; 09/841,193; 09/841,194;
09/841,195; 09/841, 238; 09/841,239; 09/841,240; 09/841,283, 09/841,284;
09/841,285; 09/841,286; 09/841,287; 09/841,288; 09/841,289; 09/841,290;
09/841,291; 09/841,292; 09/841,293; 09/841,294; 09/841,295; 09/841,296;
09/841,297; 09/841,298; 09/841,299; 09/841,300; 09/841,301; 09/841,302;
09/841,303; 09/841,304; 09/841,305; 09/841,306; 09/841,307; 09/841,308;
09/841,309; 09/841,310; 09/841,311; 09/841,312; 09/841,429; 09/841,430;
09/841,431; 09/841,432; 09/841,433; 09/841,434; 09/841,435; 09/841,436;
09/841,437; 09/841,438; 09/841,439; 09/841,440; 09/841,441; 09/841,442;
09/841,443; 09/841,444; 09/841,445; 09/841,446; 09/841,447; 09/841,448;
09/841,449, 09/841,488; 09/841,489; 09/841,490; 09/841,491; 09/841,492;
09/841,493; 09/841,494; 09/841,495; 09/841,496; 09/841,497; 09/841,498;

09/841,499; 09/841,500; 09/841,501; 09/841,502; 09/841,632; 09/841,633;
09/841,634; 09/841,635; 09/841,636; 09/841,637; 09/841,638, and 09/841,639.

Applicant respectfully traverses the provisional double patenting rejection. Applicant respectfully submits that the omnibus nature of this rejection does not provide Applicant with sufficient detail in which to address such rejection. Applicant also respectfully submits that the rejection is also inconsistent with certain restrictions issued in the above-referenced cases. Applicant respectfully requests reconsideration.

Pursuant to the discussion in the Examiner interview on August 19, 2002, for the convenience of the Examiner, Applicant will forward copies of allowed claims for the above-referenced cases to the Examiner. Applicant understands that the Examiner will review the allowed claims for the above-referenced cases and then reconsider the double patenting rejection in view of such allowed claims.

E. The Claims Are Definite Pursuant To 35 U.S.C. § 112, Second Paragraph

The Examiner rejected claims 2424-2426, 2430-2449, 2457, 2458, 2460, and 2461 under 35 U.S.C. § 112, second paragraph, “as being indefinite for failing to particularly point out and distinctly claim the subject matter which applicant regards as the invention.”

The Examiner rejected claim 2424 as being unclear, stating: “The modified “about” is not normally used in reference to an integer count (i.e., a number of sources); thus it is unclear what the scope of the claim is.” Applicant respectfully disagrees. Applicant submits that the number of heat sources per well is an average number of heat sources per production well in a unit cell of the formation. Support for this interpretation is found at least in the paragraphs of the Specification cited below.

FIG. 61 illustrates an example of a square pattern of heat sources 3000 and production wells 3002. Heat sources 3000 are disposed at vertices of squares 3010. Production well 3002 is placed in a center of every third square in both x- and y-directions. Midlines 3006 are formed equidistant to two production wells

3002, and perpendicular to a line connecting such production wells. Intersections of midlines 3006 at vertices 3008 form unit cell 3012. Heat source 3000a is completely within unit cell 3012. Heat source 3000b and heat source 3000c are only partially within unit cell 3012. Only the one-half fraction of heat source 3000b and the one-quarter fraction of heat source 3000c within unit cell 3012 provide heat within unit cell 3012. The fraction of heat source 3000 outside of unit cell 3012 may provide heat outside of unit cell 3012. The number of heat sources 3000 within one unit cell 3012 is a ratio of heat sources 3000 per production well 3002 within the formation (Specification, page 176, lines 19-29).

Thus, Applicant submits that “at least about 7 heat sources” in amended claim 2424 refers to an effective number of heat sources per production well rather than an integer number of heat sources.

The Examiner rejected claims containing the term “hydrocarbons”, stating: “While applicant may be his or her own lexicographer, a term in a claim may not be given a meaning repugnant to the usual meaning of the term.” The Examiner further states: “Applicant’s vague definition of “hydrocarbon” is much broader than the accepted meaning of the term and this makes it impossible for one of ordinary skill in the art to ascertain the scope of the claims which include the term “hydrocarbon”. Applicant respectfully disagrees.

Applicant respectfully submits that Applicant has used an accepted meaning of the term “hydrocarbon” as defined by one of ordinary skill in the art. Support for this definition can be found in references within and associated with the art of the petroleum industry. For example, a reference within the art gives the following definition: “**Hydrocarbons:** molecules formed primarily by carbon and hydrogen atoms” (Hyne, N. J. *Geology for Petroleum Exploration, Drilling, and Production*, 1984, McGraw-Hill Book Company, pg. 264). The Specification (page 30, paragraph beginning on line 1) has been amended for clarification. Applicant therefore respectfully requests removal of the rejection of Applicant’s definition of the term “hydrocarbon”.

The Examiner rejected claim 2433, stating: “Since this equation fails to take into account the endothermic nature of pyrolysis reactions, and heat loss to adjacent formations; it is not clear

how the heating energy can be equal to or less than P_{wr} .” Applicant has amended claim 2433 for clarification. Applicant respectfully submits the amendments to claim 2433 do not substantively change the scope of the claim.

The Examiner rejected claim 2447 as being unclear regarding “non-condensable component.” Applicant respectfully disagrees with the rejection. Support for “non-condensable component” is found in Applicant’s specification, which states:

Hydrocarbons in the produced fluids may include a mixture of a number of different components, some of which are condensable and some of which are not. The fraction of non-condensable hydrocarbons within the produced fluid may be altered and/or controlled by altering, controlling, and/or maintaining a temperature within a pyrolysis temperature range in a heated portion of the hydrocarbon containing formation. Additionally, the fraction of non-condensable hydrocarbons within the produced fluids may be altered and/or controlled by altering, controlling, and/or maintaining a pressure within the heated portion. In some embodiments, surface facilities may be configured to separate condensable and non-condensable hydrocarbons of a produced fluid. (Specification, page 127, lines 9-16).

Claim 2447 has been amended for clarification. Applicant submits that the amendment does not broaden the scope of the claim.

The Examiner rejected claim 2458 as unclear regarding “substantially uniformly increasing a permeability.” Applicant respectfully disagrees. Support for claim 2458 is found in the Specification, which states:

In an embodiment, a permeability of a selected section within a heated portion of a coal formation may be substantially uniform. For example, heating by conduction may be substantially uniform, and thus a permeability created by conductive heating may also be substantially uniform. In the context of this patent “substantially uniform permeability” means that the assessed (e.g., calculated or estimated) permeability of any selected portion in the formation does not vary by more than a factor of 10 from the assessed average permeability of such selected portion (Specification, page 137, lines 9-18).

Heating the portion of a coal formation, as described in any of the above embodiments, may substantially uniformly increase a porosity of a selected section within the heated portion. In the context of this patent “substantially uniform porosity” means that the assessed (e.g., calculated or estimated) porosity of any selected portion in the formation does not vary by more than about 25 % from the assessed average porosity of such selected portion (Specification, page 138, lines 22-27).

The Examiner rejected claim 2426 as being unclear regarding “a pyrolysis temperature range.” Claim 2426 has been amended for clarification. Support for this amendment can be found in Applicant’s specification which states: “In an alternative embodiment, a pyrolysis temperature range may include temperatures between about 270 °C to about 400 °C” (Specification, page 36, lines 21-22). Applicant submits that the amendment to these claims does not broaden the scope of the claims.

The Examiner rejected claim 2432 as being unclear regarding “during pyrolysis.” Applicant has amended claim 2432 for clarification. Applicant respectfully submits the amendments to claim 2432 do not substantively change the scope of the claim.

The Examiner rejected claim 2447 as being unclear regarding a “benchmark temperature and pressure.” Applicant has amended claim 2447 to include conditions of 25 °C and one atmosphere absolute pressure, as described in the definition of “non-condensable hydrocarbons” on page 33, lines 21-22 of the Specification.

F. The Claims Are Not Obvious Over Tsai In View Of Van Meurs Pursuant To 35 U.S.C. § 103(a)

The Examiner rejected claims 2424-2426, 2430, 2434-2447, 2457, 2458, and 2460 under 35 U.S.C. § 103(a) as being unpatentable over Tsai et al. (U.S. Patent No. 4,299,285, hereinafter “Tsai”) in view of Van Meurs et al. (U.S. Patent No. 4,866,118, hereinafter “Van Meurs”). Applicant respectfully disagrees.

To establish *prima facie* obviousness of a claimed invention, all the claim limitations must be taught or suggested by the prior art. *In re Royka*, 490 F.2d 981 (CCPA 1974), MPEP § 2143.03.

Amended claim 2424 describes a combination of features including: “providing heat from one or more heaters to at least a portion of the formation.” Support for amendments to the claim is found at least in the Specification as follows:

A “heater” is generally defined as any system configured to generate heat in a well or a near wellbore region. A “unit of heat sources” refers to a minimal number of heat sources that form a template that is repeated to create a pattern of heat sources within a formation. For example, a heater may generate heat by burning a fuel external to or within a formation such as surface burners, flameless distributed combustors, and natural distributed combustors, as described in embodiments herein (Specification, p. 31, lines 14-19).

Heat sources 100 may include, for example, electrical heaters such as insulated conductors, conductor-in-conduit heaters, surface burners, flameless distributed combustors, and/or natural distributed combustors. Heat sources 100 may also include other types of heaters (Specification, p. 46, lines 3-6).

Tsai discloses: “the oxidizing gas is injected into the injection hole at an appropriate rate and the fire is started in the coal bed at the injection well” (Tsai, col.2, lines 30-33). Applicant respectfully submits that Tsai does not appear to teach or suggest providing heat from one or more heaters to a part of the formation.

If an independent claim is nonobvious under 35 U.S.C. 103, then any claim depending therefrom is nonobvious. *In re Fine*, 837 F.2d 1071, 5 USPQ2d 1596 (Fed. Cir. 1988). Applicant submits, however, that many of the claims dependent on claim 2424 may be separately patentable.

The Examiner has rejected claim 2425. The Examiner states:

[T]he Tsai and Van Meurs references fail to explicitly teach the superposition of heat sources. It is apparent that one of ordinary skill in the art would know that the heat sources should be spaced to substantially heat the entire formation. Any configuration of heat sources that provides heat to the entire formation would inherently cause superposition of heat; thus it would have been obvious to one of ordinary skill in the art at the time of the invention to have further modified the Tsai method to have included superposition of heat as called for in claim 2425.

Amended claim 2425 describes a combination of features including: “wherein the one or more heaters comprise at least two heaters, and wherein superposition of heat from at least the two heaters pyrolyzes at least some hydrocarbons within the part of the formation.”

Applicant’s Specification discloses:

One or more heat sources may be located within the formation such that superposition of heat produced from one or more heat sources may occur. Superposition of heat may increase a temperature of the selected section to a temperature sufficient for pyrolysis of at least some of the hydrocarbons within the selected section. Superposition of heat may vary depending on, for example, a spacing between heat sources. The spacing between heat sources may be selected to optimize heating of the section selected for treatment. Therefore, hydrocarbons may be pyrolyzed within a larger area of the portion. In this manner, spacing between heat sources may be selected to increase the effectiveness of the heat sources, thereby increasing the economic viability of a selected in situ conversion process for hydrocarbons. Superposition of heat tends to increase the uniformity of heat distribution in the section of the formation selected for treatment (Specification, page 9, lines 4-14).

In some embodiments, a plurality of heated portions may exist within a unit of heat sources. A unit of heat sources refers to a minimal number of heat sources that form a template that may be repeated to create a pattern of heat sources within the formation. The heat sources may be located within the formation such that superposition (overlapping) of heat produced from the heat sources is effective. For example, as illustrated in FIG. 7, transfer of heat from two or more heat sources 330 results in superposition of heat 332 to be effective within an area defined by the unit of heat sources. Superposition may also be effective within an interior of a region defined by two, three, four, five, six or more heat sources. For example, an area in which superposition of heat 332 is effective includes an area to which significant heat is transferred by two or more heat sources of the unit of heat sources. An area in which superposition of heat is

effective may vary depending upon, for example, the spacings between heat sources (Specification, p. 52, lines 17-28).

Superposition of heat may increase a temperature in at least a portion of the formation to a temperature sufficient for pyrolysis of hydrocarbon within the portion. In this manner, superposition of heat 332 tends to increase the amount of hydrocarbon in a formation that may be pyrolyzed. As such, a plurality of areas that are within a pyrolysis temperature range may exist within the unit of heat sources. The selected sections 334 may include areas at a pyrolysis temperature range due to heat transfer from only one heat source, as well as areas at a pyrolysis temperature range due to superposition of heat (Specification, page 52, line 30-page 53, line 5).

In addition, a pattern of heat sources will often include a plurality of units of heat sources. There will typically be a plurality of heated portions, as well as selected sections within the pattern of heat sources. The plurality of heated portions and selected sections may be configured as described herein. Superposition of heat within a pattern of heat sources may decrease the time necessary to reach pyrolysis temperatures within the multitude of heated portions. Superposition of heat may allow for a relatively large spacing between adjacent heat sources, which may in turn provide a relatively slow rate of heating of the coal formation. In certain embodiments, superposition of heat will also generate fluids substantially uniformly from a heated portion of a coal formation (Specification, page 53, lines 7-15).

In some embodiments, superposition (e.g., overlapping) of heat from one or more heat sources may result in substantially uniform heating of a portion of a coal formation. Since formations during heating will typically have temperature profiles throughout them, in the context of this patent "substantially uniform" heating means heating such that the temperatures in a majority of the section do not vary by more than 100 °C from the assessed average temperature in the majority of the selected section (volume) being treated (Specification, page 137, lines 26-31).

Applicant submits that the cited art does not appear to teach or suggest controlled superposition.

Amended claim 2426 describes a combination of features including: "further comprising maintaining a temperature within the part within a pyrolysis temperature range of about 270 °C to about 400 °C." Amendment to claim 2426 is supported in the Specification on page 36, lines 21-22: "In an alternative embodiment, a pyrolysis temperature range may include temperatures between about 270 °C to about 400 °C." In contrast, Tsai states: "Initially, there is a

vaporization of moisture from the coal and a loss of some volatile carbonaceous material. Some of this may be the result of a minor pyrolysis of the coal” (Tsai, col. 4, lines 51-54). Applicant submits that the features of claim 2426, in combination with the features of independent claim 2424, do not appear to be taught or suggested by the cited art.

Amended claim 2430 describes a combination of features including: “wherein the one or more heaters comprise natural distributed combustors.” Tsai states: “the oxidizing gas is injected into the injection hole at an appropriate rate and the fire is started in the coal bed at the injection well” (Tsai, col. 2, lines 31-34). In contrast, Applicant’s Specification discloses:

As used herein, the phrase “natural distributed combustor” generally refers to a heater that uses an oxidant to oxidize at least a portion of the carbon in the formation to generate heat, and wherein the oxidation takes place in a vicinity proximate to a wellbore. Most of the combustion products produced in the natural distributed combustor are removed through the wellbore (Specification, page 9, lines 16-31).

Applicant submits that the cited art does not appear to teach or suggest the features of claim 2430 in combination with the features of independent claim 2424.

Claim 2434 describes a combination of features including: “wherein allowing the heat to transfer comprises transferring heat substantially by conduction.” Tsai describes:

This link or channel between wells can be naturally occurring permeability in the coal seam involving cracks, fissures and the like. But since naturally occurring paths of suitable gas flow capacity are rare, it is generally necessary by some suitable means to significantly enhance a naturally occurring path or it may be necessary to produce an artificial path for high volume, low pressure gas flow between the injection and production wells. One solution involves the fracturing of the coal bed by injecting under substantial pressure an aqueous mixture containing suitable entrained particles as propping agents to open up fracture planes and channels in which the particles settle out to prop the fractures open when the pressure is released. Another method involves the directional drilling of one or more holes through the coal bed, generally along the bottom portion of the bed, between the injection and production holes. Other linking methods or

combinations of linking methods can be used to obtain the linkage between the wells (Tsai, col. 2, lines 9-29).

Thus, Tsai does not appear to teach or suggest transferring heat substantially by conduction.

Furthermore, Tsai appears to teach in situ combustion and gasification in an area between injection wells and production wells to produce a combustible gas from the formation. Tsai discloses:

Air is heated to a temperature of about 250° C. and is injected into the injection well at a pressure of approximately 500 psi (35.2 kg/cm²) and at a rate of about 300 ft³/min (8.5 m³/min) (standardized to one atmosphere and 15.6° C.). Injection is continued at this rate for five days. Combustion air at ambient temperature is now injected into the injection hole at a pressure of 50 psi (3.51 kg/cm²) and at a rate of 1,500 ft³/min (42.5 m³/min) (standardized to one atmosphere and 15.6° C.), and a fire is ignited in the coal at the bottom of the injection well. After the underground combustion stabilizes, a combustible product gas is obtained at the production well (Tsai, col. 7, line 62-col. 8, line 17).

Applicant submits that portions of the aforementioned rejection appears to be set forth in facts within the personal knowledge of the Examiner. Applicant therefore believes MPEP 2144.03 will apply. Pursuant to MPEP 2144.03, Applicant respectfully requests the Examiner to provide support for his assertion either by an affidavit or by references brought to the Applicant's attention. Otherwise, Applicant requests this rejection be removed.

Amended claim 2435 describes a combination of features including: "wherein providing heat from the one or more heaters comprises heating the part of the formation such that a thermal conductivity of at least a portion of the part of the formation is greater than about 0.5 W/(m °C)."

Tsai appears to teach a temperature less than the softening temperature of coal. Tsai does not appear to teach or suggest that the thermal conductivity of the pyrolysis zone is greater than about 0.5 W/(m °C). Tsai states:

Since the injection of the heated air should itself not cause the coal to swell, the maximum temperature of the injected air can be up to but not the same as the temperature at which the coal begins to soften.... The range of about 150° C to about 300° C is a particularly suitable operating range (Tsai, col. 3, lines 32-45).

Whether or not “a particular combination might be ‘obvious to try’ is not a legitimate test of patentability.” *Id.* at 1599, citing *In re Geiger*, 815 F.2d 868, 688, 2 USPQ2d 1276, 1278 (Fed. Cir. 1987) and *In re Goodwin*, 576 F.2d 375, 377, 198 USPQ 871, 881 (CCPA 1981). Consequently, it is not permissible for the Examiner to “use hindsight reconstruction to pick and chose among isolated disclosures in the prior art to deprecate the claimed invention.” *Id.* at 1600. Applicant submits the features of claim 2435, in combination with the features of independent claim 2424, do not appear to be taught or suggested by the cited art.

The Examiner rejected claims 2436-2447, stating:

the nature of hydrocarbons produced from such heating is highly variable, and dependent upon many factors, not least of which is the characteristics of the coal. The components of the produced mixture are deemed to be the results of design variables, including coal characteristics and temperature. Also, specifically with respect to claims 2439-2441; hydrocarbons produced using the Tsai method inherently have less than 1% nitrogen, oxygen, or sulfur.

Tsai states, however

When the combustion is initiated in the coal seam at the injection hole to initiate the gasification procedure, a series of oxidation and reduction reactions occur, which are not thoroughly understood. The net result is a combustible product gas comprising carbon monoxide, hydrogen and some methane as its principal combustibles and having a heat content which depends on many factors including whether supplemental oxygen and/or water, are added to the oxidizing gas (Tsai, col. 5, line 52-col 6, line 1).

Thus, portions of the aforementioned rejection appear to be set forth in facts within the personal knowledge of the Examiner.

Claim 2436 describes a combination of features including: “wherein the produced mixture comprises condensable hydrocarbons having an API gravity of at least about 25°.” The features of claim 2436, in combination with the features of independent claim 2424, do not appear to be taught or suggested by the cited art.

Claim 2437 describes a combination of features including: “wherein the produced mixture comprises condensable hydrocarbons, and wherein about 0.1 % by weight to about 15 % by weight of the condensable hydrocarbons are olefins.” The features of claim 2437, in combination with the features of independent claim 2424, do not appear to be taught or suggested by the cited art.

Claim 2438 describes a combination of features including: “wherein the produced mixture comprises non-condensable hydrocarbons, and wherein a molar ratio of ethene to ethane in the non-condensable hydrocarbons ranges from about 0.001 to about 0.15.” The features of claim 2438, in combination with the features of independent claim 2424, do not appear to be taught or suggested by the cited art.

Claim 2439 describes a combination of features including: “wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is nitrogen.” The features of claim 2439, in combination with the features of independent claim 2424, do not appear to be taught or suggested by the cited art.

Claim 2440 describes a combination of features including: “wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is oxygen.” The features of claim 2440, in combination with the features of independent claim 2424, do not appear to be taught or suggested by the cited art.

Claim 2441 describes a combination of features including: “wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is sulfur.” The features of claim 2441, in combination with the features of independent claim 2424, do not appear to be taught or suggested by the cited art.

Claim 2442 describes a combination of features including: “wherein the produced mixture comprises condensable hydrocarbons, wherein about 5 % by weight to about 30 % by weight of the condensable hydrocarbons comprise oxygen containing compounds, and wherein the oxygen containing compounds comprise phenols.” The features of claim 2442, in combination with the features of independent claim 2424, do not appear to be taught or suggested by the cited art.

Claim 2443 describes a combination of features including: “wherein the produced mixture comprises condensable hydrocarbons, and wherein greater than about 20 % by weight of the condensable hydrocarbons are aromatic compounds.” The features of claim 2443, in combination with the features of independent claim 2424, do not appear to be taught or suggested by the cited art.

Claim 2444 describes a combination of features including: “wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 5 % by weight of the condensable hydrocarbons comprises multi-ring aromatics with more than two rings.” The features of claim 2444, in combination with the features of independent claim 2424, do not appear to be taught or suggested by the cited art.

Claim 2445 describes a combination of features including: “wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 0.3 % by weight of the condensable hydrocarbons are asphaltenes.” The features of claim 2445, in combination with the features of independent claim 2424, do not appear to be taught or suggested by the cited art.

Claim 2446 described a combination of features including: “wherein the produced mixture comprises condensable hydrocarbons, and wherein about 5 % by weight to about 30 % by weight of the condensable hydrocarbons are cycloalkanes.” The features of claim 2446, in combination with the features of independent claim 2424, do not appear to be taught or suggested by the cited art.

Amended claim 2447 describes a combination of features including: “wherein the produced mixture comprises a non-condensable component, wherein the non-condensable component comprises molecular hydrogen, wherein the molecular hydrogen is greater than about 10 % by volume of the non-condensable component, and wherein the molecular hydrogen is less than about 80 % by volume of the non-condensable component.” The features of claim 2447, in combination with the features of independent claim 2424, do not appear to be taught or suggested by the cited art.

Amended claim 2457 describes a combination of features, including “wherein allowing the heat to transfer comprises increasing a permeability of a majority of the part of the formation to greater than about 100 millidarcy.” Amended claim 2458 describes a combination of features including: “wherein allowing the heat to transfer comprises substantially uniformly increasing a permeability of a majority of the part of the formation.”

The Examiner states: “the Tsai reference teaches the permeability greater than about 100 md in table 1. The uniform increase in permeability is inherent.” Applicant respectfully disagrees.

Applicant submits that Tsai does not appear to teach increasing the permeability of at least a majority of the part of the formation to greater than 100 millidarcy. Tsai states: “A series of core samples from this coal were tested to determine the effect on the coal’s properties of hot air treatment at different temperatures and for different periods of time.... The data and analyses are set out in Table I” (Tsai, col. 6, lines 54-59). Permeabilities recorded in Table I are for core samples only. Applicant further submits that Tsai does not appear to teach substantially

uniformly increasing a permeability of at least a majority of the pyrolysis zone.

Tsai states: “The initial permeability of the core was 2.0, after two days it was 27.5, after three days it was 77.2 and after four days it was 107 as reported in Table I” (Tsai, col. 7, lines 11-14). In addition, Table I of Tsai discloses a permeability of 107 md for Ex. 6 and a permeability of 148 md for Ex. 7, in which the axis of the core was perpendicular to the bedding plane. Tsai does not appear to teach or suggest at least the feature of wherein allowing the heat to transfer comprises substantially uniformly increasing a permeability of a majority of the part of the formation.

Thus, Applicant submits that the features of claims 2457 and 2458, in combination with the features of independent claim 2424, do not appear to be taught or suggested by the cited art.

Claim 2460 describes a combination of features including: “providing heat from three or more heaters to at least a portion of the formation, wherein three or more of the heaters are located in the formation in a unit of heaters, and wherein the unit of heaters comprises a triangular pattern.” The features of claim 2460, in combination with the features of independent claim 2424, do not appear to be taught or suggested by the cited art.

G. The Claims Are Not Obvious Over Tsai and Van Meurs And Further In View Of Elkins Pursuant To 35 U.S.C. § 103(a)

The Examiner rejected claim 2431 under 35 U.S.C. § 103(a) as being unpatentable over Tsai and Van Meurs and further in view of U.S. Patent No. 2,734,579 to Elkins (hereinafter “Elkins”). Applicant respectfully disagrees.

Amended claim 2431 describes a combination of features including: “controlling a pressure and a temperature within at least a majority of the part of the formation, wherein the pressure is controlled as a function of temperature, or the temperature is controlled as a function of pressure.”

Elkins discloses:

Control of the temperature within the reaction zone can be maintained in several ways. The increase in volume of oxygen-containing gas by application of higher injection gas pressure will increase this temperature.... To keep the temperature from becoming too high, it is possible to dilute the air with inert gas, for example, by separating the inert gaseous products of combustion (principally oxides of nitrogen and carbon) from the produced hydrocarbons, and introducing it into the injection stream.... Decreasing the injection gas pressure also decreases the combustion zone temperature (Elkins, col. 3, lines 26-46).

Elkins appears to teach or suggest changing the pressure and/or concentration of the injected gas to control the temperature. Elkins does not appear to teach or suggest controlling a pressure and a temperature within at least a majority of the pyrolysis zone of the formation, wherein the pressure is controlled as a function of temperature, or the temperature is controlled as a function of pressure. Applicant respectfully submits that the features in claim 2431, in combination with the features of independent claim 2424, do not appear to be taught or suggested by the cited art.

H. The Claims Are Not Obvious Over Tsai and Van Meurs And Further In View Of Kasevich et al. Pursuant To 35 U.S.C. § 103(a)

The Examiner rejected claims 2432 and 2433 under 35 U.S.C. § 103(a) as being unpatentable over Tsai and Van Meurs and further in view of U.S. Patent No. 4,457,365 to Kasevich et al. (hereinafter “Kasevich”). Applicant respectfully disagrees.

Kasevich states: “this invention provides for heating kerogen in oil shale with electric fields having frequency components in the range between 100 kilohertz and 100 megahertz where dry oil shale is selectively heated, with kerogen-rich regions absorbing energy from said fields at substantially higher rates than kerogen-lean regions” (Kasevich, col. 2, lines 9-15).

Tsai states: “This invention relates to the in situ combustion and gasification of a swelling bituminous coal by the injection of air for combustion into the coal bed from one or more injection holes and the production of a combustible gas from one or more production holes.” (Tsai, col. 1, lines 6-10)

Obviousness can only be established by “showing some objective teaching in the prior art or that knowledge generally available to one of ordinary skill in the art would lead that individual to combine the relevant teaching of the references.” *In re Fine*, 837 F.2d 1071, 5 USPQ2d 1596, 1598 (Fed. Cir. 1988). Applicant respectfully submits that the features of the electric field heating method of Kasevich for an oil shale formation would not be suitable for modifying the in situ combustion process of Tsai for a coal formation to produce the features described in claims 2432 and 2433.

Amended claim 2432 describes a combination of features including: “controlling the heat such that an average heating rate of the part of the formation is less than about 1 °C per day within a pyrolysis temperature range of about 270 °C to about 400 °C.”

Kasevich states: “Thus, if the kerogen were heated from 150 °C. to 500 °C. at the rate of 50 °C./month, the absorption rate would approximate that of curve 114 [in Figure 3], while more rapid heating rates would produce curves 120, 122 and 124 for heating rates of 50 °C. per month, 50 °C./day, 50 °C./hour and 50 °C./minute, respectively” (Kasevich, col. 8, lines 57-62). Figure 3 of Kasevich shows a heating rate of 50 °C/month, which may correspond to an average heating rate of about 1.6 °C/day. Kasevich does not appear to teach or suggest a heating rate of less than 1 °C/day during pyrolysis. The Examiner states, however: “It is apparent that when the temperature reaches its highest point (the point at which pyrolysis occurs) the rate of increase would be at the slowest; thus it would be less than about 1 °C/day.” Applicant respectfully submits that the Examiner appears to be using personal knowledge to extend the teaching of Kasevich. Applicant submits that the cited art does not appear to teach or suggest the features of claim 2432 in combination with the features of independent claim 2424.

Amended claim 2433 describes a combination of features including: “wherein heating energy/day (P_{wr}) provided to the selected volume is equal to or less than $h \cdot V \cdot C_v \cdot \rho_B$, wherein ρ_B is formation bulk density, and wherein an average heating rate of the formation (h) is about 10 °C/day.” Applicant submits that the cited art does not appear to teach or suggest the features of claim 2433 in combination with the features of independent claim 2424.

I. The Claims Are Not Obvious Over Tsai And Van Meurs And Further In View Of Salomonsson Pursuant To 35 U.S.C. § 103(a)

The Examiner rejected claim 2461 under 35 U.S.C. § 103(a) as being unpatentable over Tsai and Van Meurs and further in view of U.S. Patent No. 2,914,309 to Salomonsson (hereinafter “Salomonsson”). Applicant respectfully disagrees.

Amended claim 2461 describes a combination of features including: “providing heat from three or more heaters to at least a portion of the formation, wherein three or more of the heaters are located in the formation in a unit of heaters, wherein the unit of heaters comprises a triangular pattern, and wherein a plurality of the units are repeated over an area of the formation to form a repetitive pattern of units.” The features of claim 2461, in combination with the features of the independent claim 2424, do not appear to be taught or suggested by the cited art.

J. The Claims Are Not Obvious Over Tsai And Van Meurs And Further In View of Stoddard et al. Pursuant To 35 U.S.C. § 103(a)

The Examiner rejected claims 2448 and 2449 under 35 U.S.C. § 103(a) as being unpatentable over Tsai and Van Meurs and further in view of U.S. Patent No. 4,463,807 to Stoddard et al. (hereinafter “Stoddard”). Applicant respectfully disagrees.

Claims 2448 describes a combination of features including: “wherein the produced mixture comprises ammonia, and wherein greater than about 0.05% by weight of the produced

mixture is ammonia.”

Stoddard discloses: “A seal against water incursion serves two purposes: water is excluded from the georeactor and the processes underway, and water soluble products of reactions (phenols, ammonia and the like) are excluded from the aquifer” (Stoddard, col. 3, lines 28-31).

Applicant submits that Stoddard, in combination with Tsai and Van Meurs, does not appear to teach or suggest a produced mixture with an ammonia content of greater than 0.05%. Thus, the features of claim 2448, in combination with the features of independent claim 2424, do not appear to be taught or suggested by the cited art.

Claim 2449 describes a combination of features including, “wherein the produced mixture comprises ammonia and wherein the ammonia is used produce fertilizer.” Applicant submits that the features of claim 2449, in combination with the features of independent claim 2424, are not taught by the cited art.